

**VEGETABLE RESEARCH
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**Vegetable Production
Series**



BROCCOLI PRODUCTION IN CALIFORNIA

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PRODUCTION AREAS AND SEASONS

Although broccoli (*Brassica oleracea* L. var. *italica*) has been grown in Europe for centuries, it has only become an important vegetable crop in the United States since 1925. California has four main broccoli production areas: the southern desert valleys (Imperial and Riverside Counties); the southern coast (Ventura, Santa Barbara, and San Luis Obispo Counties); the central coast (Monterey, San Benito, and Santa Cruz Counties); and the Central Valley (Fresno, Kern, Stanislaus, and Tulare Counties). Monterey County is by far the leading broccoli producing county in the state with half of the acreage and production. The south coast has 30 percent of the acreage, while the desert valleys and the Central Valley each account for 10 percent.

In the Imperial Valley broccoli is planted from early September through early December for harvest from early December through mid-March. Broccoli is grown year-round in the coastal valleys with a slight dip in December in both planting and harvest. In the San Joaquin Valley broccoli planting begins in mid-July and continues through January; however, most planting ends in October. The major harvest is from mid-October through December with less acreage being harvested through April.

BROCCOLI ACREAGE AND VALUE

Year	Acreage	Average yield (tons/acre)	Gross value/acre
1994	117,737	6.8	\$3,828
1993	116,860	6.9	\$3,370
1992	123,712	6.8	\$3,329

Source: Annual California County Agricultural Commissioners' Report Data (Sacramento: California Department of Food and Agriculture, 1992–1995).

CLIMATIC REQUIREMENTS

Broccoli is a hardy, cool-season vegetable in the mustard family. It is closely related to cauliflower and cabbage, and the cultural requirements for all are similar. Broccoli seed will germinate and grow from 40° to 95°F (4° to 35°C), but optimum growth is obtained when monthly air temperatures average from 60° to 65°F (16° to 18°C).

In commercial plantings under optimum conditions, large leafy plants produce a compact flower head on a tall, green, branching stalk. The center flower head is from 3 to 8 inches (7.5–20 cm) in diameter, and plants average 12 to 24 inches (30–60 cm) tall. Desirable broccoli has small uniform beads, good blue-green to green color, and tight, dome-shaped heads that stand above the leaves for ease of harvest. Hollow stems, water head rot, brown or yellow beads, bracts within heads, uneven bead size, and excessive branching are undesirable.

VARIETIES

All commercial broccoli produced in California are hybrids of the Italian green type, also called green sprouting broccoli or calabrese. Varieties of this type have been selected that take from 50 to 150 days to grow from planting to marketable maturity. The varieties differ in color and size of plant, size of head, and extent to which side shoots (small lateral heads) develop below the terminal head.

Although broccoli is a cool-season vegetable, substantial production occurs in the hot interior and desert valleys of California that have cooler winters than the coast. Proper varietal selection for each planting period and area is critical to obtaining high yields and desirable head quality.

Principal broccoli varieties currently grown in California include, in the coastal valleys, Everest, Greenbelt, Legacy, Marathon, Ninja, Olympia, Pinnacle, Pirate, Republic, Shogun, and Sultan; in the desert valleys, Arcadia, Captain, Emperor, Everest, Galaxy, Galleon, Greenbelt, Major, Marathon, Ninja, Packman, Patriot, Pirate, and Sultan; and in the San Joaquin Valley, Arcadia, Captain, Everest, Greenbelt, Legacy, Legend, Marathon, Pirate, and Republic.

PLANTING

Until recently all fields in the Imperial and San Joaquin Valleys were direct seeded. Now, as in the coastal valleys, 25 percent of the acreage is transplanted, and this acreage is increasing. Almost all broccoli, whether direct seeded or transplanted, is grown in double rows on raised beds 38 to 42 inches (95–105 cm) wide. Spacing between seedlines is 12 to 14 inches (30–35 cm). Broccoli is occasionally planted in single rows on 30-inch (75-cm)

beds with plant spacing at 5 to 6 inches (12.5–15 cm). A typical broccoli planting is approximately 50,000 plants per acre (127,000 per ha). When direct seeded, broccoli is planted with seeding rates of 1 to 1½ pounds of seed per acre (1.1–1.7 kg/ha). Seeding depth ranges from ⅛ to ¾ inch (3–19 mm), but most growers aim for ½ inch (12 mm).

SOILS

Although broccoli grows best on well-drained soils, it may be grown on a wide range of soil textures. Fields with light soils are often designated for winter/spring crops to minimize potential harvest delays caused by rain. Broccoli has greater salt tolerance than most other common vegetables including melons, corn, lettuce, peppers, onions, and carrots. A 25 percent yield reduction can be expected with a soil salinity of 6 ECe (dsm⁻¹ at 25°C).

IRRIGATION

Broccoli is irrigated in a variety of ways in all growing regions. Sprinkler or furrow irrigation can be used from stand establishment through harvest. Many growers use sprinkler irrigation through seed emergence or to set the transplants, then switch to furrow or drip irrigation for the remainder of the season. Approximately 2 to 3 acre-feet (2,480–3,700 cu. m) of water is needed to grow a broccoli crop. The amount and frequency of sprinkler or furrow irrigation depends on soil type, environmental conditions, crop production area, and maturity. A small amount of acreage is grown under drip irrigation.

FERTILIZATION

Broccoli is moderately to heavily fertilized. The rate of fertilizer should be chosen with consideration of soil type, recent cropping history, and soil test results, which help indicate phosphorus (P) and potassium (K) requirements. The test for bicarbonate extractable phosphorus estimates how much P is available to plants. Soils above 30 ppm do not generally require additional P; however, when planting in cold soils, P is less available to plants so applications of P may be necessary. Soils with ammonium acetate extractable K values greater than 150 ppm do not generally require additional K. Preplant phosphorus applications vary from 50 to 250 pounds P₂O₅ per acre (56–280 kg/ha). The higher rates are broadcast prior to listing the beds. Lower rates are applied in a band 2 to 3 inches (5–7.5 cm) to the side and below the seed row after bed formation and prior to seeding.

Total nitrogen (N) applied to the crop ranges from 100 to 200 pounds per acre (112–224 kg/ha). About 50 pounds per acre (56 kg/ha) of N is applied preplant with an additional 50 to 150 pounds per acre (56–168 kg/ha) sidedressed or water-run in one to three applications throughout the season. The type of N used varies with the environment. Ammonium sulfate and urea are common dry fertilizers in warm climates, while CAN-17

(calcium ammonium nitrate, 17-0-0) is water-run during cold, wet weather. AN-20 (aqua ammonia, or liquid ammonium nitrate, 20-0-0) and UAN-32 (urea-ammonium nitrate, 32-0-0) are other common water-run N sources. Plant tissue sampling of the midribs of young, mature leaves at broccoli bud formation can help determine if the fertilizer program is adequate. When dry tissue analysis reveals less than 7,000 ppm NO₃-N, 2,000 ppm PO₄-P, or 2 percent K, an application of fertilizer would likely improve quality and yield.

INTEGRATED PEST MANAGEMENT

Integrated pest management (IPM) information is continually being developed for weed, insect, and disease problems in California broccoli. Cultural control methods such as mechanical cultivation, field sanitation, good drainage, and irrigation management to avoid excessively wet soils are important components of IPM that help minimize chemical controls. Herbicides, insecticides, and fungicides should always be used in compliance with label instructions. Consult DANR Publication 3307, *IPM for Cole Crops and Lettuce*, and the UC IPM *IMPACT Pest Management Guidelines for Cole Crops* for more detailed information about broccoli pest identification, biology, and management.

Weed management. Regional differences in weed problems are significant. In the coastal areas winter and spring weeds favored by cool, moist conditions predominate for most of the year. In the Imperial and San Joaquin Valleys early crops compete with weeds that germinate in warm to hot conditions from midsummer to late fall. Later fall and winter plantings compete with annual winter weeds. Common problem weeds in all areas include burning nettle (*Urtica urens*), sowthistle (*Sonchus oleraceus*), prickly lettuce (*Lactuca serriola*), shepherd's purse (*Capsella bursa-pastoris*), London rocket (*Sisymbrium irio*), chickweed (*Stellaria media*), nightshade (*Solanum* spp.), purslane (*Portulaca oleracea*), and nutsedge (*Cyperus* spp.). Nearly all fields are treated with preplant and/or preemergence herbicides and are mechanically cultivated. Consult your Farm Advisor for advice as registered herbicides change often. A post-emergence application of a grass herbicide, a directed spray of ammonium nitrate fertilizer, or hand hoeing are sometimes required.

Insect identification and management. A wide variety of invertebrate pests can cause extensive damage to broccoli. Cabbage and seedcorn maggots (*Delia* sp.), flea beetles (*Phyllotreta* sp. and *Epitrix cucumeris*), wireworms (*Elateridae* sp.) and cutworms (*Agrostis* sp. and *Peridroma saucia*) are common seedling pests that may require control. The cabbage aphid (*Brevicoryne brassicae*), the green peach aphid (*Myzus persicae*), and several species of worms can build to damaging levels on leaves of young plants; however, economic damage is rare on older plants unless contamination of the harvested broccoli is at issue. The silverleaf whitefly (*Bemisia argentifolii*) has caused significant damage to fields in the Imperial

Valley but only isolated incidences have been observed elsewhere in the state.

Early-season plantings in the Imperial and San Joaquin Valleys are more likely to be attacked by seedling pests and worms than are late-season plantings. Broccoli planted in the coastal valleys must be monitored on a year-round basis to determine if population pressures warrant an insecticide application. General UC recommendations discourage heavy use of broad-spectrum insecticides because they destroy the complex of beneficial insects that often keep pest populations in check. Consult your Farm Advisor or licensed pest control advisor with a specific problem. Chemicals that may legally be used to control these pests change frequently.

Nematodes and disease identification and management. Soilborne pests that are significant yet relatively isolated and rare include the cyst (*Heterodera* sp.) and root knot (*Meloidogyne* sp.) nematodes and the fungal pathogen *Plasmidiophora brassicae*, which causes club root disease. These can be controlled by field selection, crop rotation, and soil fumigation. Seedling damping-off diseases caused by *Rhizoctonia solani* or *Phytophthora megasperma* occur sporadically and are managed by cultural practices such as avoiding excessively wet soils during early stages of seedling growth and not transplanting too deeply. Downy mildew (*Peronospora parasitica*) is a common fungal disease in broccoli. Though symptoms (leaf spots and foliar damage) are obvious in the field, economic loss is rare unless young seedlings are severely attacked or the disease is systemic in mature heads. Some growers never apply a fungicide for this disease, while others frequently do. Chemical treatment is usually only necessary to protect young seedlings during wet weather that favors disease. Other leaf-spot diseases occur on broccoli but are rarely significant. Broccoli head rot caused by *Pseudomonas* bacteria or *Alternaria* sp. fungi can cause severe economic loss for which there is no real control other than copper sprays as a preventative measure.

HARVEST AND HANDLING

Broccoli is grown for both fresh and processed markets. Market price sometimes determines how broccoli is harvested—a crop may be hand-harvested two to three times depending upon market price and quality. Value-added fresh broccoli products range from special crown cuts, spears, and fresh florets to broccoli slaws for use in prepack and other convenience-food items destined for

export, food service, and domestic consumers. Broccoli is increasingly being exported to Japan and other Pacific Rim markets that require special harvesting and packing but offer premium prices.

Fresh market broccoli is field packed. The standard pack consists of heads that average 3 to 8 inches (7.5–20 cm) in diameter. Crews cut or snap the stems at 8 inches (20 cm) and place the heads on a harvest-aid belt. Two to four heads are bunched, secured with a rubber band, and cut to a uniform 7 inches (17.5 cm). Fourteen or eighteen bunches of broccoli are packed in a waxed-fiberboard carton that weighs a minimum of 23 pounds (10.4 kg). Crown-cut broccoli consists of a top dome 5 to 5½ inches (12.5–13.7 cm) in diameter cut from the stem at 5 inches (12.5 cm). A packed carton consists of 34 to 38 bulk-packed crowns and weighs a minimum of 20 pounds (9 kg). Field-cut florets are loosely packed in mesh bags and packed into cardboard cartons that weigh 9 to 18 pounds (4–8 kg) and contain three to four bags each. Broccoli destined for the freezer is also hand-harvested. The stem is cut at 6 inches (15 cm), slightly shorter than for fresh market. The heads are placed on belts, then collected into large bins or trailers and hauled to the processor.

POSTHARVEST HANDLING

Broccoli requires rapid cooling to preserve quality and maximize shelf life. Harvested cartons should be taken immediately to the cooler and never allowed to sit too long on the dock before cooling. Liquid icing is the standard cooling method. Immediately after icing, broccoli should be put in refrigerated storage. Bunched broccoli stored at 32°F (0°C) with a relative humidity of 95 percent will typically have a shelf life of 10 to 14 days.

MARKETING

Approximately 110,000 acres (43,300 ha) of broccoli is grown annually in the United States for fresh and processed markets with a value of \$260 million in the early 1990s. California produces about 90 percent of the broccoli grown in the United States; Arizona, Texas, and Oregon also provide supplies. Demand for broccoli is increasing both domestically and internationally. From 1984 to 1994, broccoli acreage remained relatively stable while crop value increased by more than 40 percent. This achievement is attributed to higher prices for “value added” broccoli for export, food service, and domestic consumer markets.

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